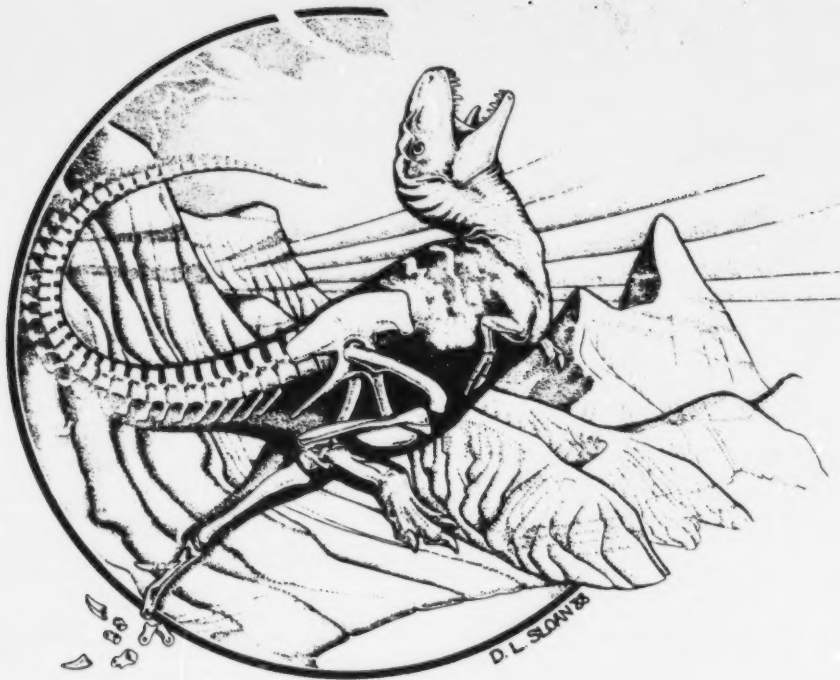




Society of Vertebrate Paleontology

48th Annual Meeting

FIELD TRIP "B" (October 12, 1988)

**PALAEOECOLOGY OF UPPER CRETACEOUS
JUDITH RIVER FORMATION AT DINOSAUR PROVINCIAL PARK,
ALBERTA, CANADA**

OCCASIONAL PAPER OF THE TYRRELL MUSEUM OF PALAEONTOLOGY, #7

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FIELD TRIP ITINERARY

October 12, 1988

- 10:00 am STOP #1 **Overlook at Dinosaur Provincial Park:**
Greeting and introduction.
- 10:30 STOP #2 **Field Station of Tyrrell Museum of
Palaeontology:** Tour of displays.
- 11:15 STOP #3 **Regional Disconformity at BB 86 parking
area.**
- 12:00 pm STOP #4 **Centrosaurus** **Bonebed:** Lunch, dinosaurs,
and taphonomy.
- 2:15 STOP #5 **Bonebed 31:** Vertebrate microfossil
assemblages, pisidiid-dominated molluscan
assemblage.
- 3:30 STOP #6 **Small Theropod Quarry:** Altered volcanic
ashes, sedimentology, Judith River/Bearpaw
transition.
- 4:45 STOP #7 **Display House #4:** In-situ dinosaur display
(TIME ALLOWING).
- 5:15 **FIELD TRIP COMPLETED**
- 6:00 **Steak-Pit at Patricia Hotel:** Western-style
supper.

FOREWORD

This field trip has been organized to expose the participants to as full a range of current and past palaeoecological research in Dinosaur Provincial Park as possible within a one day time limit (including a dinner stop at the Patricia Hotel's Steak-Pit). Because time is limited, the guidebook organization reflects the sequence of stops rather than major research topics. Those participants who desire a more detailed and topic-specific reference for the palaeontology and geology of Dinosaur Provincial Park may wish to purchase a copy of the 1987 GAC Field Trip Guidebook (Koster and others, 1987) from:

The Department of Geological Sciences,
University of Saskatchewan,
Saskatoon, Saskatchewan S7N 0W0.

\$15.00/copy and \$2.00 handling.

This field trip comprises 7 stops including a visit to the new Field Station of the Tyrrell Museum of Palaeontology -- a display, research, and resource facility situated in the Park. There are 4 field trip leaders (Dave Eberth, Emlyn Koster, Phil Currie, and Donald Brinkman) and a variety of topics will be discussed at each stop. The guidebook does not attempt to cover topics in detail but rather provides a brief outline of the topics and an integrated summary for each stop. Much of what will be seen and discussed during the field trip represents research that is in varying stages of completion.

Within this context we hope to generate enthusiastic and productive discussions during and between stops and we heartily encourage your participation.

D.A.E.

1.0 STOP #1:

OVERLOOK

DAVID A. EBERTH

1.1 INTRODUCTION:

Located 48 kilometers north of Brooks (Alberta), just off the Trans-Canada Highway, Dinosaur Provincial Park encompasses 75 km² of terrain characterized by sweeping prairies, cottonwood dominated river-margin habitats, and deeply incised badlands that have yielded world renowned fossil resources (Fig. 1). Bordering the Red Deer River, this unique and beautiful combination of modern and ancient resources has made the Park one of Western Canada's most popular recreation areas. Worldwide recognition was officially achieved in 1979 when Dinosaur Provincial Park was designated a UNESCO World Heritage Site joining such distinguished company as the Grand Canyon and Great Barrier Reef. The Park was also nominated in 1984 as one of the hundred best geological sites in the Rocky Mountains Section of the Geological Society of America as a part of the Decade of North American Geology project.

1.2 STRATIGRAPHY:

Dinosaur Provincial Park contains excellent badlands-style exposure of essentially flat-lying mid-Campanian (Judithian land mammal age) Judith River Formation strata (Oldman and Foremost formations, McLean, 1971)(Fig. 2). Subsurface data indicate that the entire Judith River Formation is approximately 250 m thick in the vicinity of Dinosaur Provincial Park (MacDonald and others, 1987).

Exposures along the valley walls of the Red Deer River are typically 60-100 m thick and in the eastern portion of the Park record a transgression from the fluvial facies of the Judith River Formation up through paralic and marine facies of the Lethbridge Coal Zone and Bearpaw Formation respectively (Koster, 1984). This transgressive sequence forms the base of the Bearpaw Cycle (sensu Kauffman, 1977) -- the last major transgressive/regressive cycle of the Western Interior Sea in Western Canada. Radioisotopic analyses (K-Ar and $\text{Ar}^{40}\text{-Ar}^{39}$) of biotites and feldspars collected from bentonites in the Park indicate an age of 74-76 Ma for the Park sediments (Eberth and others, in press).

1.3 SEDIMENTARY GEOLOGY:

The Judith River Formation is a channel-dominated coastal plain sequence comprising muddy to pebbly, fine- to coarse-grained multistoreyed channels, massive mudstones, ironstones, minor coals and carbonaceous shales (Koster and others, 1987). To date, virtually all of the sedimentological studies of the Judith River Formation exposures in the Park have focused on the coarse-grained members (channel deposits). Koster (1984) and Koster and others (1987) have presented evidence that the diversity of palaeochannel types seen in the Dinosaur Provincial Park exposures represents a spectrum of estuarine environments ranging from proximal, high sinuosity reaches to distal, low sinuosity reaches. Two basic "types" of palaeochannel have been described. Type I palaeochannels dominated by inclined heterolithic stratification (IHS) (Thomas and others, 1987) and comprising sand-mud couplets reflect rhythmic

alternating deposition of coarse-grained bedload and fine-grained suspended sediments, largely under the influence of diurnal, tidally-induced backwater effects in the upper, high sinuosity (meandering) reaches of the estuarine channels. Type II palaeochannels comprise cleaner, trough cross-bed-dominated deposits and are interpreted as having formed in the straight reaches of the lower estuarine setting (close to palaeoshore) under fluctuating, relatively high energy flow. Type I and II palaeochannels represent endpoints in a spectrum of channel types including three additional and definable intermediate types (A, B, and C).

Wood (1985), in a detailed sedimentological study of a smaller area within Dinosaur Provincial Park ("Cathedral" area) has argued that fluctuating discharge was responsible for the development of IHS sand-mud couplets in Type I channels and that the Type I and II palaeochannel deposits of Koster (1984) and Koster and others (1987) comprise genetically related though spatially distinct portions of a single, freshwater, high sinuosity fluvial system, not proximal or distal portions of estuarine channels.

It is universally accepted by all researchers who have worked with the Dinosaur Provincial Park sediments that many additional site-specific studies in this area and studies of modern analogues will have to be conducted before a more complete sedimentological picture emerges.

1.4 PALAEOLOGY:

The palaeontological resources of Dinosaur Provincial Park are remarkably diverse and numerous. Taken together, few localities on Earth can boast of similar riches. The vertebrate assemblage alone comprises approximately 130 species. With the inclusion of plants and invertebrates, over 200 species of Campanian age plants and animals occur as fossils in the Dinosaur Provincial Park sediments (Tables 1,2,3, and 4).

At the present time over 35 species of dinosaurs are known from the Park and new discoveries continue to be made yearly. Besides the spectacular dinosaur occurrences, 32 different taxa of fish, 10 taxa of amphibians, 29 taxa of non-dinosaurian reptiles, 1 bird, and 20 taxa of mammals are presently known from the Park. Many of these forms have yet to be described suggesting that basic taxonomic and systematic work will continue to be an important aspect of palaeontological research in Dinosaur Provincial Park for many years hence.

While the vertebrates certainly comprise the most numerous and dramatic component of the fossil assemblage from the Park, invertebrates, in the form of non-marine molluscs, were probably a common part of the community. Unfortunately, widespread penecontemporaneous dissolution of CaCO_3 appears to have been a common phenomenon and, at present, few localities are known to produce shelly invertebrates. Insects in amber are known from other Upper Cretaceous beds in southern Alberta, and one site is now known from the Judith River Formation beds just outside the Park

boundary. A sample of this amber is on display in the Field Station of the Tyrrell Museum of Palaeontology, in Dinosaur Provincial Park.

Non-marine trace fossils are particularly common in exposures below the disconformity throughout Dinosaur Provincial Park and compare well with similar assemblages present in stratigraphically equivalent beds of the Judith River Formation throughout southern Alberta. These trace fossils have received little to no attention, and their study may help to delineate subtle differences in relative rates of basin subsidence, sediment input, and reworking in the Judith River Formation in southern Alberta.

Macroplant fossils are uncommon in Dinosaur Provincial Park and are best represented by fossilized trunks that occur as allochthonous components of channel sandstones. Leaf compression fossils are only rarely encountered and typically occur in association with sideritized silt- and sandstones, carbonaceous mudstones and bentonites. Macroplant fossils include members of Taxodiaceae, Cupressaceae, Metasequoia, and Cercidiphyllum (Koster and others, 1987). In contrast, the palynological assemblage comprises at least 85 taxa (Jarzen, 1982; Table 4).

1.5 TAPHONOMY:

Taphonomic studies were begun in Dinosaur Provincial Park with the pioneering work of Peter Dodson almost twenty years ago (Dodson, 1970, 1971). During the 1970's, however, very little additional palaeoecological and taphonomic work was carried out in Dinosaur Provincial Park. Recently, a number of studies have been completed that attempt to merge sedimentological, stratigraphic and

palaeontological data to produce coherent, modern taphonomic interpretations of the sediments and fossils in Dinosaur Provincial Park (e.g. Brinkman, 1987; Currie and Dodson, 1984; Koster and Currie, 1987; Koster and others, 1987; Visser, 1986; Wood, 1985; Wood and others, 1988). Site-specific taphonomic interpretations will be the subject of many of the following stops.

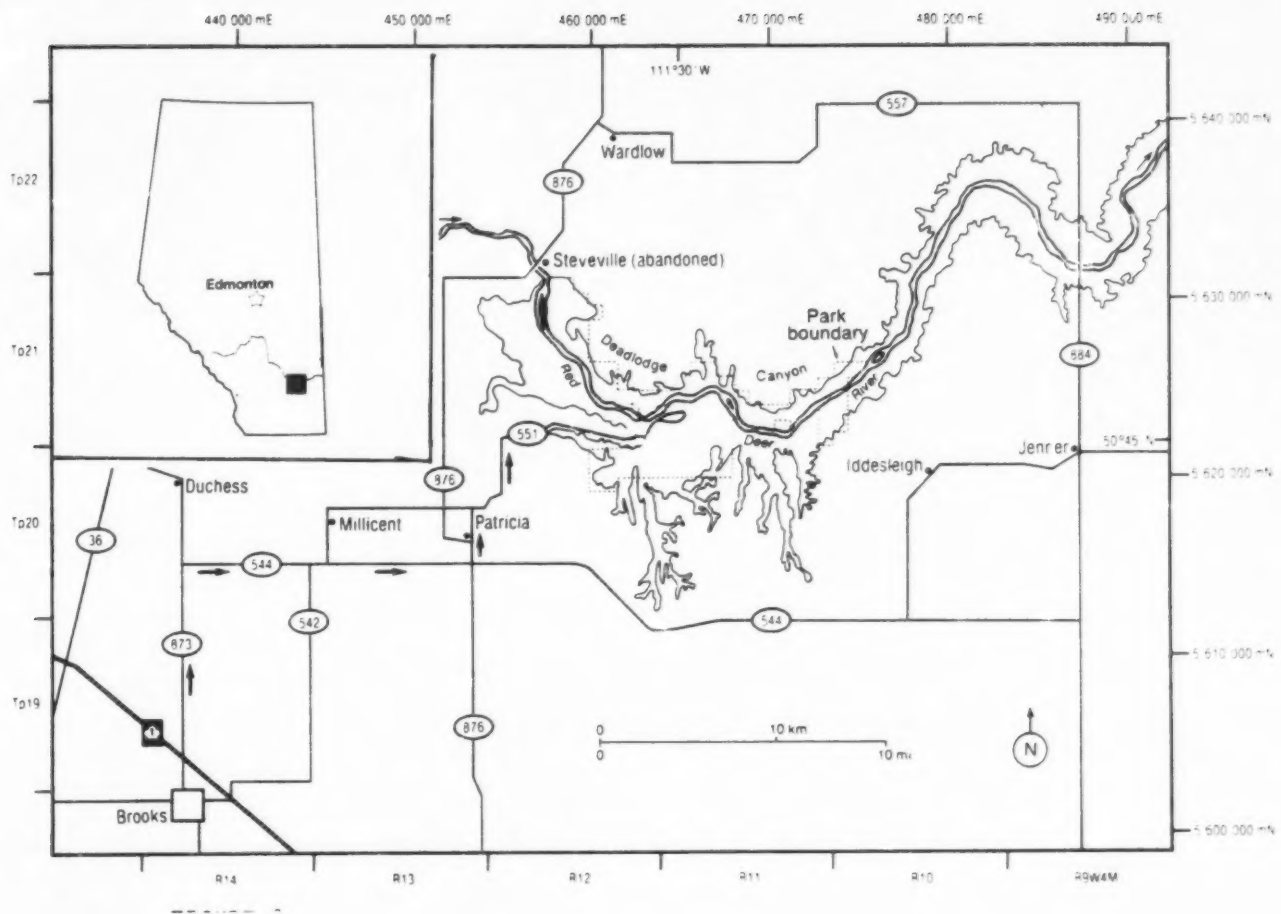


FIGURE 1. Access from Brooks on the Trans-Canada Highway to Dinosaur Provincial Park. The irregular solid line enclosing the course of the Red Deer River shows the distribution of badlands. Dotted line indicates Park boundary.

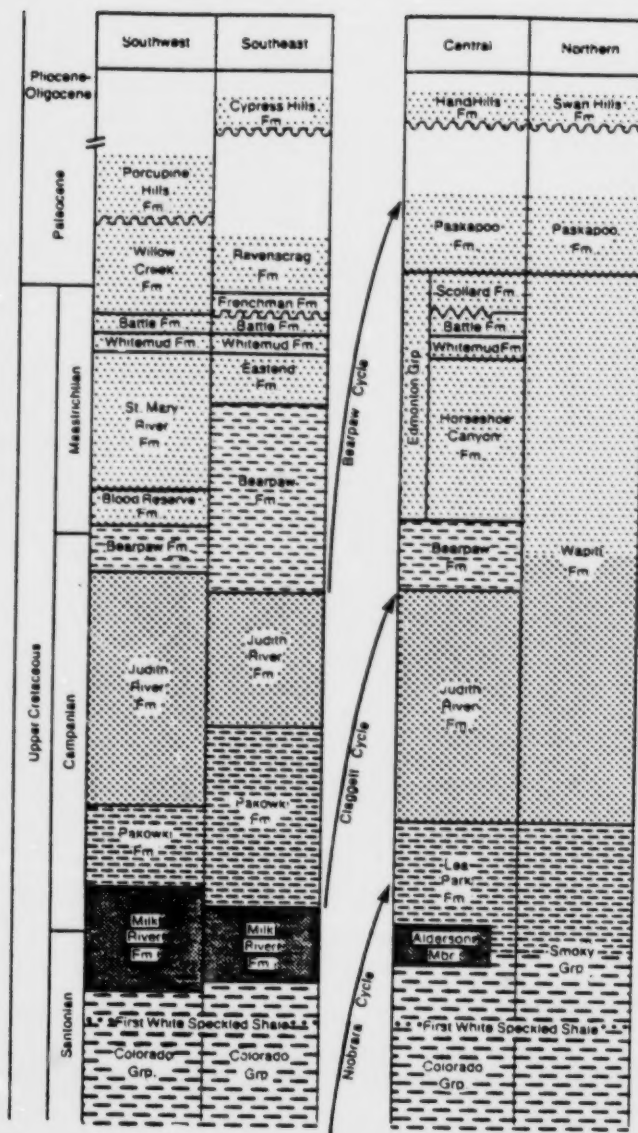


FIGURE 2. Upper Cretaceous and Tertiary stratigraphy of Alberta. Stratigraphy in Dinosaur Provincial Park and vicinity corresponds to that of 'Central Alberta' in the figure. From Koster and others (1987).

2.0 STOP# 2

FIELD STATION OF THE TYRRELL MUSEUM OF PALAEONTOLOGY

David A. Eberth

A forty-five minute stop at the new Field Station of the Tyrrell Museum of Palaeontology is included in the field trip. The Field Station, which opened May 15, 1987, is both a display and research facility whose purpose is to support research and conservation in Dinosaur Provincial Park. The facility comprises approximately 250 m² of display space and 500 m² of research, preparation, and resource space. Researchers work out of the Field Station during the summer and some specimen preparation and cataloguing can be performed prior to storage of specimens at the Tyrrell Museum. The Tyrrell Museum shares the Field Station with Visitor Services of the Alberta Department of Recreation and Parks. During the summer, Visitor Services personnel present a variety of natural history and palaeontology programs and offer guided tours of the Park and its resources.

Displays at the Field Station are organized palaeoecologically with major treatments of aquatic, terrestrial and paralic environments, and dinosaur diversity. The regional palaeogeographic framework of the Upper Cretaceous of southern Alberta is briefly explained and exhibits on the origin and natural history of the badlands round out the story.

3.0 STOP #3

REGIONAL DISCONFORMITY

DAVID A. EBERTH

3.1 REGIONAL DISCONFORMITY:

Of particular interest with respect to questions of foreland evolution in southern Alberta and the abundance of dinosaur fossils in Dinosaur Park is the presence of a regional disconformity in the lower one-half of the exposed Judith River section in the Park.

Recent study of sedimentologic, petrologic, petrographic, and palaeontologic features across this disconformity in southern Alberta (Eberth, in preparation) demonstrates that the disconformity records a major Cordilleran uplift event west-northwest of Dinosaur Park.

Passing upward and across the disconformity:

- average maximum grain size is greater;
- extraformational pebbles comprising quartzites, cherts and metamorphics appear;
- sandstones are less mature (higher rock fragment/quartz ratios);
- multistoreyed channels are thicker and occur more frequently in vertical section;
- channel sandstones are more sheet-like and less ribbon-like;
- IHS (inclined heterolithic stratification) facies appears;
- large-scale trough cross-beds are thicker and laterally more extensive;
- mean paleocurrent directions change from north-northeast to west-southwest.

Below the disconformity:

- horizontal to low-angle inclined stratification is common;
- ripple lamination is abundant;
- silicified, reworked ash deposits (tuffs) are present;
- continental trace fossils (arthropods) are common;
- articulated dinosaurs are rare.

These observations have resulted in the formulation of the hypothesis that a major uplift in the Cordillera west-northwest of Dinosaur Park established a new style of basinal sedimentation in the foreland. This new style was characterized by:

- relatively higher rates of sediment input;
- relatively higher rates of foreland subsidence;
- a switch from seasonal to more perennial fluvial systems;
- wetter environments;
- deeper, broader, more sinuous channels;
- reduced floodplain exposure times.

The timing of the uplift event is particularly interesting with respect to the onset of the transgression of the Bearpaw sea (onset of Kauffman's, 1977, Bearpaw T/R cycle). Preliminary assessment of subsurface and surface data from eastern Alberta and western Saskatchewan indicates that the uplift and onset of transgression are concurrent events. If so, eustasy need not necessarily be invoked to explain the Bearpaw transgression in Western Canada.

From a paleoecologic and taphonomic perspective it is interesting to note that of the more than 100 articulated dinosaur specimens mapped by C. M. Sternberg (1950) only 2 occur below the disconformity. Although there is certainly more exposure of the

Judith River Formation above the disconformity it is unlikely that hypsometry alone can explain this discrepancy in the stratigraphic distribution of articulated dinosaur fossils. Furthermore, vertebrate microfossil sites (sorted assemblages of small, disarticulated vertebrate elements) occur in abundance both above and below the disconformity.

At present, the most reasonable hypothesis is that changes across the disconformity in the preservation of articulated dinosaurs are related to the changes in the style of basin sedimentation. Higher rates of sediment input, deeper river channels, larger scale bedforms, less sediment reworking and reduced floodplain exposure times would all serve to enhance the chances that a large dinosaur carcass would be preserved. However, detailed study of this problem is yet necessary to test this hypothesis.

4.0 STOP #4

THE DINOSAUR PROGRAM

PHILIP J. CURRIE AND EMLYN H. KOSTER

4.1 INTRODUCTION:

Dinosaur Provincial Park has long been renowned as one of the world's major sources of Upper Cretaceous dinosaur specimens (Table 1). More than three hundred significant finds have been made, and dinosaurs from this region are on display in more than thirty institutions throughout the world. The majority of these specimens were collected between 1912 and 1925, the period of the so-called "Great Canadian Dinosaur Rush", after which collecting activities were curtailed. Since 1978, however, there has been steady increase in collecting and research in Dinosaur Provincial Park, primarily by the Tyrrell Museum of Palaeontology, with assistance from scientists from the National Museum of Natural Sciences (Ottawa), University of Pennsylvania, University of Calgary and the Alberta Research Council. Correlations with other Judithian sites in Alberta and Montana is being refined as detailed work on the stratigraphy, depositional environments and faunal and floral assemblages increases our understanding of the ancient ecosystems (Dodson, 1983).

In addition to scientists, a large crew of Tyrrell Museum technicians and volunteers work in Dinosaur Provincial Park every summer. They are divided into smaller teams who either prospect and record data on new fossil resources, excavate significant specimens, or continue a long-term excavation program at the

Centrosaurus bonebed (Quarry #143; Currie, 1982). These surveying teams retain the type of field interests of pioneer palaeontologists during the "Great Dinosaur Rush" in terms of display and research quality articulated specimens. Indeed, over the past five years superb specimens of Albertosaurus, Centrosaurus, Kritosaurus, Gryposaurus, Chasmosaurus, Corythosaurus, Lambeosaurus and Troodon have been collected. But current Tyrrell Museum practice is broader, with the following four types of dinosaur resources now being researched: 1) "quarries" (removed articulated specimens or rare smaller remains), 2) "uncollected articulated dinosaurs" (so-called UAD's -- prospects discovered, but not yet quarried), 3) "bonebeds" (bedding-plane concentrations of commonly abraded, fragmented and disarticulated remains), and 4) "microsites" (surface and subsurface concentrations of fine-sized disarticulated remains). The main purpose of all collections data is to establish population counts for palaeoecological and taphonomic interpretation. However, the Tyrrell's approach is not new. In the 1940's C.M. Sternberg marked quarries in the Park with a brass plate set on a post and recorded content, locality, and elevation data. The resulting publication (Sternberg, 1950) proved to be very influential in the early stages of the "dinosaur renaissance" more than two decades later, and provided data for the first studies on dinosaur taphonomy and physiology. The Tyrrell Museum has reinitiated the practice of staking quarries found since 1950.

4.2 CENTROSAURUS BONEBED:

The Centrosaurus bonebed (Quarry #143) was discovered by Park officials in 1977, and systematic grid excavations by Tyrrell Museum personnel began two years later (Currie, 1981; Currie and Dodson, 1984). After nine summers of excavations, only about 25% of the Centrosaurus bonebed has been excavated. Present estimates suggest that the total number of individuals represented in the entire bonebed may exceed three to four hundred. Covering at least 1,500 m² and spanning up to 1.5 m in an upward fining, thick palaeochannel sequence with ironstones, wood fragments and extraformational pebbles, the spatial density of bone locally reaches 60 elements/m². The long axes of most bones are oriented parallel to the horizontal and many elements show preferred current alignment. Long bone elements at lower elevations are commonly aligned transverse to flow, and some vertebrae are imbricated! The size distribution averages 17.3 cm, and shows positive skewness.

Between 85-95% of the identifiable material is ceratopsian, and diagnostic ceratopsian skull elements, with one exception, can be referred to Centrosaurus -- hence the name of the bonebed. Based on an early sample of 525 elements (as of the 1981 field season), the composition of the remaining assemblage is 5% carnivorous dinosaur, 3.5% hadrosaur, 1.5% champsosaur, 0.5% ankylosaur, 0.5% turtle, 0.5% Myledaphus, and 2.5% mammals, lizards and other fish. By contrast, in the rest of the Park, ceratopsians comprise less than 25% of the dinosaur assemblage. Examination of other sites throughout Alberta shows that there are also monogeneric bonebeds containing Anchiceratops, Chasmosaurus, Monoclonius, Pachyrhinosaurus, and

Styracosaurus. The fact that ceratopsians tend to be found in large monogeneric bonebeds suggests either that the bonebeds accumulated over a long period of time and that the animals lived in different areas or that the bonebeds formed rapidly from the mass deaths of herds. Mass deaths of herding herbivores such as Connochaetes, Rangifer, and Bison are common in both fossil and historical records. Anatomically, the dinosaurian component of the bonebed comprises about 50% ribs, 20% vertebrae, 15% skull parts, 10% limbs and small numbers of foot and girdle fragments.

To date at least 70 individuals have been identified in the Centrosaurus bonebed. These range in size from small (possibly yearlings) up to very large individuals. Study of the size distribution of the specimens produces a number of results. First, the majority of animals in the bonebed are young adults. If mortality was attritional rather than catastrophic, one would expect to find the weakest individuals (juveniles and old animals) to be dominant in the death assemblage simply because the average-sized animals would tend to be healthy and less susceptible to death. Second, there are three size ranges known from the 70 individuals recovered. Three of these are very small and five appear to be almost double this size, with no individuals between these two sizes. The remaining animals are at least 50% larger than those in the second size range.

Similar size distributions exist in the modern organisms that breed seasonally. For example, caribbean turtles sampled one month after hatching produce three size categories: small, one month old juveniles; yearlings that are twice the size of the juveniles; and adults. Most vertebrates tend to double their size within their first

year of life. The following year, however, the growth rate slows and two year old animals are only about 50% larger than the yearlings. After two years, the growth rate is so slow that it is masked by individual variation. That is, a male that is two years old may be larger than a female that is three years old. By analogy, the best explanation for the size distribution pattern seen in the Centrosaurus bonebed is that:

1. Centrosaurus bred on an annual or other regular basis (The Campanian climate of western Canada appears to have been seasonal based on observations of growth rings in the bones of crocodiles and champsosaurs, and in trees.)
2. All animals represented in that particular bonebed died at approximately the same time.
3. The smallest specimens represent animals that are less than a year old.

If evidence continues to support these hypotheses as excavation continues, then other kinds of information can be obtained. For example, it will be possible to calculate the growth rate of ceratopsians for the first few years of life. This in turn could indicate something of the physiology of horned dinosaurs. Furthermore, it will be possible to see what changes take place in morphology and proportions of the skeleton as the animals grew.

It is uncertain what caused the death of the herd of Centrosaurus. Perhaps it was flood, perhaps it was drought, or it may even have been disease. However, we do know that after death,

carcasses were scavenged by carnivorous dinosaurs. These carnivores lost teeth while feeding, which are found mixed among the bones of the ceratopsians. Tooth-marked bone has been recovered from the bonebed. Carnivores also trampled bones of the herbivores, creating green-bone fractures. It would appear that the skeletons then were exposed for a time, allowing the bones to disassociate completely as the connective tissue rotted away. After scavenging and disarticulation, the bones were hydraulically sorted and many elements were preferentially oriented relative to the flow of the water.

5.0 STOP #5

BONEBED 31

DAVID A. EBERTH, DONALD BRINKMAN AND PAUL A. JOHNSTON

5.1 VERTEBRATE MICROFOSSIL ASSEMBLAGES:

Upper Cretaceous vertebrate microfossil sites comprising concentrated assemblages of disarticulated skeletal elements from a variety of small to large vertebrates are important sources of palaeoecological data (Estes, 1964; Sahni, 1972). Vertebrate microfossil sites are particularly abundant in the exposures of the Judith River Formation in Dinosaur Provincial Park. At present, over 50 sites are known. Combined palaeontological and sedimentological study of some of these sites is now underway in an attempt to assess their palaeoecological significance. Bonebed 31 was selected to exemplify microsite research because of a number of interesting features: 1) It was the first dinosaur egg shell locality to be found in Dinosaur Provincial Park and possesses a seemingly anomolous assemblage of vertebrates microfossils relative to many other vertebrate microfossil sites higher in section, 2) It possesses a striking example of a locally developed pisidiid-dominated mollusc assemblage and, 3) It is a beautifully preserved though uncommon example of a non-channel, fossiliferous, depositional environment.

Sediment collected in large volume from Bonebed 31 has been screenwashed as part of an ongoing survey of vertebrate microfossil assemblages. This survey has shown that a number of patterns of stratigraphic change in abundance of vertebrates occurs throughout the exposures of the Judith River Formation in Dinosaur Provincial

Park. These stratigraphic distributions are interpreted as a result of ecological zonation of the coastal plain in which the beds were laid down, with the animals that have a similar distribution being members of the same paleoecological zone.

Three paleocommunities can be recognized on the basis of the distribution of the taxa through the Judith River Formation. The first is characterized by taxa that are most abundant low in section or are restricted in their distribution to the lower beds. These taxa comprise bony fish (Kindlea, Coriops, an esocoid, Holostean 'A' and "deep dent."-- the last two being undescribed forms), amphibians (frogs and the salamanders Scapherpeton and Opisthotriton), and an hypsilophodont dinosaur (cf. Thescelosaurus). Bonebed 31 conforms to this paleocommunity.

The second is characterized by the fish Paratarpon, chelydrid turtles, the soft-shelled turtle Aspideretes, Basilemys, and ceratopsians. These taxa are restricted to the upper beds or increase in abundance through the lower and middle beds with a significant decrease in abundance in the upper ten meters of the formation.

The third assemblage is characterized by taxa restricted to the upper beds of the formation or that increase in abundance upwards through the sequence and include the shark Hybodus, the ray Myledaphus, the gar and sturgeon (Lepisosteus and Acipenser), baenid turtles and the soft-shelled turtle Aspideretes, and the crocodile Leidyosuchus.

Future studies may provide data that will help in ascertaining the underlying causes of these statistically significant stratigraphic distributions.

5.2 SEDIMENTOLOGY:

BB 31 occurs within a 1.5 m thick fining-upward lithosome of locally contorted carbonaceous sediments that displays a crude horizontal lamination and locally developed ripple lamination. The lithosome is sheet-shaped and has been mapped over 550 m SW-NE and 250 meters NW-SE. In all directions it is erosionally truncated by channel deposits. The fossiliferous site occurs in association with iron-rich (sideritic) sediments and a locally concentrated deposit of disarticulated pisidiid clam valves and rare unionids. A sheet-shaped geometry, the presence of horizontally stratified sediments as well as the absence of scour and lag deposits and large-scale stratification all indicate that the lithosome was deposited in a non-channel, relatively quiet water environment. Small-scale sandstone lenses and laminae are present and together with disarticulated vertebrate microfossils and invertebrate fossils indicate occasional high flow velocities. Numerous abrupt contacts between laminae and lenses indicate that this area was repeatedly inundated by flood waters but the fining-upward nature of the deposit, as well as the thinning-upward nature of the beds and laminae suggests that, through time, this area was abandoned (autocyclically).

5.3 INVERTEBRATE PALAEOLOGY:

The locally dense accumulation of a pisidiid-dominated mollusc assemblage is of particular interest in this deposit. The assemblage is dominated by the thin-shelled pisiddid bivalve, Sphaerium recticardinale (Meek and Hayden). Small high-spined prosobranch

gastropods form a lesser component and unionid shells (invariably disarticulated) are rare. With few exceptions, the pisidiid shells are disarticulated and many are fragmentary indicating at least moderate reworking. The limited lateral extent of the shell horizons (~10 meters) in contrast to the relatively extensive nature of the lithosome indicates that the pisidiid's source bed(s) must have been very close to the environment of deposition. Inspection of the adjacent and underlying fine-grained facies have failed to yield any evidence of in-situ pisidiids, however, this is not unexpected because, to date, all known occurrences of invertebrates with aragonite shells in Dinosaur Provincial Park have been found within uncompacted ironstone beds suggesting that it is only in these early diagenetic chemical environments that the shells are protected from dissolution. Living pisidiids are shallow-burrowing suspension feeders with the respiratory margin oriented at or near the sediment/water interface. They typically inhabit ephemeral or permanent lentic (quiet-water) environments. Locally concentrated pisidiid valves suggest that intermittent floodwaters swept through a local community of pisidiid clams carrying them a short distance on the floodplain. After each flood the invertebrate community was reestablished. Over time, either flood waters became less competent carrying fewer clams (considered unlikely) or the invertebrate community disappeared from this area.

6.0 STOP # 6

SMALL THEROPOD QUARRY

DAVID A. EBERTH, PHILIP J. CURRIE, AND DENNIS BRAMAN

6.1 INTRODUCTION:

In 1980, the partial skeleton of a small theropod was discovered at this site. Study of the specimen showed that Chiostenotes and "Macrophalangia" are congeneric, and suggested that Chiostenotes is a caenagnathid (Currie and Russell, 1988). The small theropod quarry area (Quarry # 145) provides an opportunity to examine and/or discuss additional stratigraphic, sedimentological and paleontological features of Dinosaur Park including (1) altered volcanic ash deposits that have now yielded the first K-Ar radioisotopic dates for the Park sediments and the Judith River Formation in Alberta (Eberth and others, in press), (2) macroplant fossils and previous palynological studies (3) paleochannel deposition (based on Wood, 1985 -- one of the few detailed sedimentological studies to be completed in Dinosaur Park), (4) and, finally, the Judith River/Bearpaw transition (Lethbridge Coal Zone).

6.2 BENTONITES:

Thirteen separate bentonite (altered volcanic ash) localities comprising six stratigraphically discrete bentonite horizons have been identified in the exposures in and around the Park. Attempts are now underway to date biotites and sanidines from many of these beds (Eberth and others, in press; Thomas and others, in preparation). At the present time K-Ar dates derived from biotites have been obtained from a 40 cm thick bentonite overlying Quarry

145. A weighted mean age of 75.37 ± 0.96 Ma has been obtained for this bed. K percentages analysed in that study range from 6.80 to 7.15, and thus the dates are considered reliable. A weighted mean date of 74.19 ± 0.94 Ma is also available from a bentonite bed at the base of the Bearpaw Formation, 37 m higher in stratigraphic section. This date is conformable with K-Ar dates that were determined for the onset of the Bearpaw transgression by Folinsbee and others (1964, 1965) and Nascimbene (1965). Based on these preliminary data it is possible to speculate that the entire exposed sequence in Dinosaur Provincial Park was deposited over an interval of 2-3 million years.

6.3 PALEOBOTANY AND PALYNOLOGY:

Upper Cretaceous strata in the Drumheller and Dinosaur Provincial Park areas have been studied for over a century but the plant fossils, particularly megaplants, are not yet documented in any detail. Some of the known plants have been illustrated in Bell (1949, 1965), but the nomenclature is probably dated and no comprehensive recent work is available. Here in Dinosaur Provincial Park, the Judith River Formation contains relatively little macroplant material (Table). The main kinds appear to be Taxodiaceae, Cupressaceae, Metasequoia, and Cercidiphyllum. Well preserved leaf floras are associated with channel sandstones, interchannel mudstones and ironstone concretions. Macrofloral remains in channel sediments, with the exception of abraded large logs of coniferous trees, are generally compressed and totally carbonized. Amber is also quite commonly encountered in laminated channel

sands, and in a few localities attains high concentration. The most common form of macrofloral remains within mudstone units are unidentifiable flecks of carbonized plant material and thin rootlet systems. In-situ tree roots, compared to the Drumheller area, are exceedingly rare.

At this stop, macroplant compression fossils have been found at the basal contact of the altered volcanic ash bed and the underlying claystone. Leaves of Plantanus, and Sequoites have been identified (Thomas and others, in preparation). The rarity of macroplant fossils generally in the Judith River Formation and Dinosaur Park specifically suggests that further study of the plant assemblage at this locality is warranted.

Plant microfossils give a more detailed picture of the paleofloras (Table 3). Jarzen (1982) described palynomorphs recovered from turtle shell matrix and sediment samples. He listed a total of 85 taxa from the Park representing mosses, hornworts, liverworts, clubmosses, Selaginellales, ferns, cycads, conifers, Ephidraceae and a wide variety of angiosperms typical of the Aquilapollenites floral province (Herngreen and Chlonova, 1981). Waldman and Hopkins (1970) recovered a suite of palynomorphs from coprolites interpreted as being from a carnivore. The meagre fossil plant record appears to indicate a warm humid temperate or subtropical climate for this area during the middle to late Campanian.

6.4 SEDIMENTOLOGY:

Wood (1985) studied and described the sedimentological aspects of the 50 m thick Judith River Formation exposures from the "Cathedral" area -- an area including Quarry 145. He identified six erosionally-based rhythms each composed of four basic lithofacies: 1) trough cross-bedded sandstone (TX), 2) large-scale inclined heterolithic strata (IHS; sensu Thomas et al., 1987), 3) large-scale inclined bedded sandstones (IBS), and 4) shale (SH).

IHS and IBS units were interpreted as the remains of laterally accreting point bars within meandering, freshwater-dominated coastal plain rivers. TX sequences were interpreted as channel bottom and lower point bar sediments genetically related to overlying IHS or IBS units. Palaeochannels were reconstructed with bankfull depths of 7-25 m and widths of 55 m to over 120 m. SH sequences were interpreted as a variety of floodplain deposits including fluviolacustrine units and immature palaeosols.

Wood's (1985) interpretation differs from those of previous authors who have envisaged a spectrum of coexisting channel types ranging from 'braided' to meandering (represented by TX and IHS units respectively) (Dodson, 1971, Koster and others, 1987). It also differs significantly from Koster and others (1987) who have postulated that the Dinosaur Park palaeochannels were estuarine in character and subject to tidal influences. As mentioned earlier in this field guide, much additional study of the sedimentological aspects of the Park's exposures now need to be undertaken to resolve these differences of interpretation.

6.5 JUDITH RIVER/ BEARPAW TRANSITION:

To the southeast along the prairie break, thin seams of lignite mark the occurrence of the Lethbridge Coal Zone(LCZ) -- a sequence of lagoonal deposits delineating the western margin of the Western Interior Seaway. Up to 25 m thick in this area, the LCZ can be traced throughout southern Alberta as a regional marker horizon.

Radioisotopic dates from the base of the Bearpaw Formation (Folinsbee and others, 1964; 1965; Nascimbene, 1965) indicate that the Bearpaw transgression flooded the low lying Cretaceous coastal plain from the Cypress Hills west to Lethbridge over a span 1 million years. This relatively high rate of transgression has been the basis for using the LCZ as a chronostratigraphic marker horizon at least in southern Alberta. Ammonites, arthropods, a variety of marine clams, and shark teeth are common palaeontological features of the LCZ and the overlying Bearpaw Formation in Dinosaur Park.

7.0 STOP #7

DISPLAY HOUSE#4

DAVID A. EBERTH

Display House #4 was built to showcase a virtually complete skeleton of Corythosaurus, excavated in 1965 by Charles Hazelius Sternberg from the sandstone ridge 10 m east of the Display House. Skin impressions are preserved and the association of the specimen with large-scale trough cross-bedding as well as subtle differences in preservation between right and left sides have resulted in an interesting and educational taphonomic exhibit. The original skull has been removed to the collections section of the Tyrrell Museum of Palaeontology and a cast put in its place.

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TABLE 1: Vertebrate faunal list of the Upper Judith River Formation in Southern Alberta.

CHONDRICHTHYES

Holocephali

Chimaeriformes

Chimaeridae
Rhiochimaeridae

Ischyodus bifurcatus
Elasmodus cf greenoughi

Elasmobianchii

Selachii

Hybodontidae

Hybodus montanensis
Hybodus storeii

Euselachii

Synechodontidae

Synechodus andersoni
Synechodus striatus

Anacoracidae
Orectolobidae

Squalicorax kaupi
Eucrossorhinus

microcuspidatus

Cretorectolobus olsoni

Hemiscyllidae

Chiloscyllium missouriensis

Odontaspidae

Hypotodus grandis

Cretoxyrhinidae

Odontaspis sangiunei

Pseudotriakidae

Plicatolamna arcuata

Rhinobatidae

Archaeotreakis rochelleae

Rajiformis

Sclerochynchidae

Protoplatyrhina renae

Batoidae

Ichthyrhiza cf avoncola

Ichthyrhiza mira

Incertae Sedis

Ptychotrygon blainensis

Dasyatidae

Myledaphus bipartitus

OSTEISHTHYES

Acipenseriformes

Acipenseridae

Acipenser albertensis

Polyodontidae

Paleopsephurus sp.

Aspidorhynchiformes

Aspidorhynchidae

Belonostomus longirostris

Lepisosteiformes

Lepisosteidae

Atractosteus occidentalis

Amiiformes

Amiidae

Kindlea sp.

Semionotiformes

incertae sedis

gen et sp unident

(Holostean A)

gen et sp unident

(Holostean B)

Elopiiformes

Elopidae

Paratarpon apogerontus

Albulidae

Coriops amnicolus

?Elopiiformes

Phylodontidae

Paralbula casei

Osteoglossomorpha

Hyodontidae

gen et sp. indent

Salmoniformes

Esocidae sedis

gen et sp. indent

Acanthopterygii

incertae sedis

gen et sp indent

AMPHIBIA

Salientia

Ascaphidae

Gen. et sp. nov.(Fox)

Discoglossidae

cf. Scotiophyrne

Pelobatidae

Eopelobates

Caudata

Scapherpetontidae

Scapherpeton tectum

cf. Lisserpeton bairdi

Amphiumidae

Proamphiuma sp.

Batrachosauroiidae

Opisthotriton kayi

Prodesmodon copei

Sirenidae

Habrosaurus dilatus

Allocaudata

Albanerpetontidae

Albanerpeton sp.

REPTILIA

Chelonia

Baenidae

Neurankylus eximus
Boremys pulchra
Naomichelys speciosa
Plesiobaena antiqua
"Clemmys" cf. C. bachmani

Macrobaenidae
Dermatemydidae

Adocus lineolatus
Basilemys variolosa
Aspideretes foveatus
Aspideretes alleni

Trionychidae

Gen. et sp. indet.
Gen. et sp. indet.
Champsosaurus natator

Sauropterygia
Archosauromorph
Sauria

Chelydridae
Polycotylidae
Champsosauridae
Testudinidae

Chamops
Leptochamops denticulatus
Sauriscus

Scincidae
Anguidae
Xenosauridae
Necrosauridae

Pancelosaurus
Gen. et sp. indet.
Parasaniwa

Sauria inc. sed.
Ophidia
Crocodilia

Varanidae

Paraderma
Colpodontosaurus
Palaeosaniwa canadensis
Gen. et sp. nov. (Fox)

Aneliidae
Crocodylidae

Coniophis
Leidyosuchus canadensis
Albertochampsia langstoni
Quetzalcoatlus sp.
Gen. et sp. indet.

Pterosauria

Pterodactyloidea

cf. Erlikosaurus
Dromiceiomimus samueli
Ornithomimus edmontonicus
Struthiomimus altus

Saurischia

Segnosauridae
Ornithomimidae

Troodon formosus
(Stenonychosaurus inequalis)
(Pectinodon bakkeri)

Dromaeosauridae

Dromaeosaurus albertensis
Saurornitholestes langstoni
(Paronychodon lacustris)

cf. Dromaeosauridae
Caenagnathidae

Caenagnathus collinsi
Caenagnathus sternbergi
Chirostenotes pergracilis
(Macrophalangia canadensis)
Elmsaurus elegans

cf. Caenagnathidae

Tyrannosauridae

Albertosaurus libratus
Daspletosaurus torosus
Gracile tyrannosaur
(Aublysodon sp.)

Ornithischia

Hadrosauridae

Brachylophosaurus canadensis
Gryposaurus notabilis
Kritosaurus incurvimanus
Prosaurolophus maximus
Corythosaurus casuarius
Lambeosaurus lambei
Lambeosaurus magnicristatus
Parasaurolophus walkeri

	Hypsilophodontidae	<u>Thescelosaurus</u> cf. <u>I. neglectus</u>
	Pachycephalosaurid	<u>Gravitholus albertae</u> <u>Ornatolitholus browni</u> <u>Pachycephalosaurus</u> sp. <u>Stegoceras validus</u> Full-domed form, undescribed
	Nodosauridae	<u>Panoplosaurus mirus</u> <u>Edmontonia longiceps</u>
	Ankylosauridae	<u>Euoplocephalus tutus</u>
	Ceratopsidae	<u>Anchiceratops</u> sp. <u>Centrosaurus apertus</u> <u>Chasmosaurus belli</u> <u>Chasmosaurus kaiseni</u> <u>Eoceratops canadensis</u> <u>Monoclonius lowei</u> <u>Styracosaurus albertensis</u>
AVES		
cf. Neognathae	Apatornithidae	<u>Aptornis</u> sp
MAMMALIA		
Multituberculata	Neoplagiulacidae	<u>Cimexomys judithae</u> <u>Mesodma primaeva</u>
	Cimolodontidae	<u>Cimolodon electus</u> <u>Cimolodon similis</u>
	Cimolomyidae	<u>Cimolomys clarki</u> <u>Meniscoessus major</u> Gen. et sp. indet.
Theria inc. sed.	Deltatheridiidae	cf. <u>Deltatheroides</u>
Marsupialia	Didelphidae	<u>Alphadon praesagus</u> <u>Alphadon halleyi</u> <u>Alphadon</u> , n. sp.
	Pediomyidae	<u>Pediomys clemensi</u> <u>Pediomys</u> , n. sp.
	Stagodontidae	<u>Boreodon matutinus</u> <u>Eodelphis cutleri</u> <u>Eodelphis browni</u>
Eutheria/Insectivora	Leptictioidea	<u>Gypsonictops lewisi</u>
	cf. Nyctitheriidae	<u>Paranyctoides sternbergi</u>
	Palaeoryctidae	<u>Cimolestes</u> sp. Gen. et sp. nov. (Fox)

Table 2: Comparison of the proportions of dinosaur remains in microsites and as represented by articulated specimens (P. Dodson written communication). Adjusted proportions (second column) are the proportions of dinosaurs exclusive of pachycephalosaurids.

ARTICULATED ADJUSTED MICROFAUNA

Hadrosaur	41.0%	45.5%	45.0%
Ceratopsian	22.3%	24.7%	26.4%
Anklyosaur	11.9%	13.3%	8.2%
Pachycephalosaur	10.0%	---	0.1%
Coelurosaur	3.2%	3.6%	4.9%
Ornithomimid	4.8%	5.4%	2.3%
Tyrannosaur	6.8%	7.5%	13.1%
Total theropod	14.8%	16.5%	20.3%

Number of specimens	310	279	4931
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TABLE 3: Representative non-marine molluscs of the upper Judith River Formation slightly amended from Russell (1964); higher taxonomic assignments based on Moore (1969) for bivalves, and LaRocque (1953) and Hartman (1984) for gastropods.

Class Bivalvia

Subclass Palaeoheterodonta

Order Unionoida

Family Unionidae

Pleurobema? humei (Dyer)

Rhabdotophorus senectus (White)

Anodonta propatoris (White)

Quadrula? primaevus (White)

Lampsilis? consueta (Whiteaves)

Fusconaia? danae (Meek and Hayden)

Subclass Heterodonta

Order Veneroida

Family Pisidiidae

Sphaerium recticardinale Meek and Hayden

Order Myoidea

Family Corbulidae

Corbula confiniensis Russell

Class Gastropoda

Subclass Prosobranchia (gill-breathing, aquatic snails)

Order Mesogastropoda

Family Viviparidae

Viviparus nidaga Dyer

Family Hydrobiidae

Micropyrgus higdoni (Russell)

Family Pleuroceridae

Lioplacodes praecursa (Dyer)

L. judithensis (Stanton)

Goniobasis sublaevus (Meek and Hayden)

G. gracilentia (Meek and Hayden)

Subclass Pulmonata (Lung-breathing snails)
 Order Basommatophora (Predominately aquatic species)
 Family Physidae
 Physa canadensis Whiteaves
 Order Stylommatophora (Terrestrial species)
 Family Polygyridae
 Polygyra venerabilis Russell
 Family Grangerellidae
 Prograngerella sperata Russell

TABLE 4: Record of megaplant fossils from the upper Judith River Formation from Bell (1965).

Artocarpus sp.
Dombeyopsis nebrascensis
Elatocladus albertaensis
Menispermities sp.
Platanus affinis
Platanus latiloda
Sequoia sp.
Vitis stantoni

TABLE 6: Record of palynomorph species from the upper Judith River Formation at Dinosaur Provincial Park with suggested botanical relationships. Listed taxa have been taken unedited from Jarzen (1982), denoted J, and Waldman and Hopkins (1970), denoted W.

BRYOPHYTA	
Family Sphagnaceae	<u>Cingutritiles clavus</u> (J)
	<u>Stereisporites antiquasporites</u> (J)
ANTHOCEROTOPHYTA	
Family Anthocerotaceae	<u>Foraminisporis wonthaggensis</u> (J)
HEPATOPHYTA	
Family Spaerocarpaceae	<u>Aequitriradites ornatus</u> (J)
	<u>A. spinulosus</u> (J)
MICROPHYLLLOPHYTA	
Lycopodiales	
Family Lycopodiaceae	<u>Lycopodiumsporites</u> sp. (W)
	<u>Retitritiles austroclavatidites</u> (J)
	<u>R. nidus</u> (J)
Selaginellales	
Family Selaginellaceae	<u>Acantotritiles varispinosus</u> (J)
	<u>Heliosporites kemensis</u> (J)
	<u>Neoraistrickia truncatus</u> (J)

PTERIDOPHYTA

Filicales

Family Osmundaceae

Baculatisporites comaumensis (J)
Osmundacidites wellmanii (J)

Family Schizaeaceae

Cicatricosisporites hallei (J)
cf. Klukisporites sp. (W)
Lygodiosporites sp. (W)
cf. Schizaea sp. (W)

Family Gleicheniaceae

Gleicheniidites senonicus (J)
Gleicheniidites sp. (W)

Family polypodiaceae

Laevigatosporites adiscordatus (J)
L. discordatus (J)
L. druggii (J)
L. ovatus (J)
L. sp. (W)
L. sp. (W)
Polypodiisporites amplus (J)

Family Cyatteaceae/Dicksoniaceae

Cyathidites australis (J)
C. minor (J)

Insertae sedis

cf. Triplanosporites sp. (W)

CYCADOPHYTA

Cycadales

Pteridospermales

Family Caytoniaceae (extinct)

Vitreisporites pallidus (J)

CONIFEROPHYTA

Conferales

Family Pinaceae

Alisporites bilateralis (J)
Cedripites cretaceus (J)
cf. Pinus sp. (W)
Pityosporites sp. (J)
Tsugaepollenites sp. (W)

Family Podocarpaceae

Parvisaccites radiatus (J)
Podocarpidites granulatus (J)

Family Phyllocladaceae

Lygistepollenites sp. (J)

Family Taxodiaceae/Cupressaceae

Taxodiaceapollenites hiatus (J)

GNETOPHYTA

Family Ephedraceae

Equisetosporites multicostatus (J)

ANTHOPHYTA

Family Buxaceae

Erdtamanipollis procumbentiformis (J)

Family Cercidiphyllaceae

Cercidiphyllites brevicolpatus (J)

Family Gunneraceae

Tricolpites reticulatus (J)

Family Liliaceae

Liliacidites mirus (J)

L. morrinensis (J)

L. varigatus (J)

L. sp. (W)

L. sp. (W)

Family ?Araceae

Arecipites sp. (W)

Family Typhaceae

Typha sp. (W)

Family Loranthaceae/Santalaceae

Aquilapollenites amplus (J)

A. asper (J)

A. attenuatus (J)

A. calvus (J)

A. clarireticulatus (J)

A. pyriformis (J)

A. quadrilobus (J)

A. reticulatus (J)

A. trialatus (J)

A. tripodiformis (J)

A. turbidus (J)

A. sp. (W)

Cranwellia striata (J)

Loranthacites catteralli (J)

Scollardia sp. (W)

Family Protaceae

Beaupreaidites angulatus (J)

B. oculatus (J)

Proteacidites thalmanii (J)

Family Symplocaceae

Symplocoipollenites vestibulum (J)

Family ?Anacardiaceae

Pulcheripollenites narcissus (J)

Insertae sedis

Tricolpopollenites sp. 1 (W)

T. sp. 2 (W)

T. sp. 3 (W)

T. sp. 4 (W)

T. sp. 5 (W)

T. sp. 6 (W)

Tricoloporopollenites sp. 1 (W)

T. sp. 2 (W)

T. sp. 3 (W)

T. sp. 4 (W)

T. sp. 5 (W)

T. sp. 6 (W)

T. sp. 7 (W)